STUDIES RELATED TO WILDERNESS

MINERAL–RESOURCE EVALUATION OF THE ROUND LAKE WILDERNESS STUDY AREA, PRICE AND VILAS COUNTIES, WISCONSIN

GEOLOGICAL SURVEY BULLETIN 1512

Mineral-Resource Evaluation of the Round Lake Wilderness Study Area, Price and Vilas Counties, Wisconsin

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An evaluation of the mineral potential of the area

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88–577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness, wilderness study, and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of these areas are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys of wilderness study areas constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of national forest land in the Round Lake Wilderness Study Area, northern Wisconsin, that is being considered for wilderness designation (Public Law 93–622, January 3, 1975). The area studied is in the Chequamegon National Forest in Price and Vilas Counties.

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SUMMARY

The Round Lake Wilderness Study Area, part of the Chequamegon National Forest in Price and Vilas Counties, Wis., contains peat equivalent to 760,000 short tons of air-dried commercial-quality peat suitable for agricultural purposes. The deposits are in several bogs (fig. 7) and occupy an area of 227 acres, in which the peat ranges from 5 to 15 ft in thickness. This peat probably contains the heating value of 420,000 short tons of coal. The relative inaccessibility of the area and the long distance to markets, coupled with the abundance of similar deposits elsewhere in the region, make the commercial potential of these peat deposits low. For the same reasons, extensive sand and gravel deposits in the region have very low commercial potential.

The study area is in a belt of volcanic rocks that in general has a high potential for massive sulfide deposits similar to several economically important deposits recently discovered elsewhere in northern Wisconsin. Geochemical and geophysical surveys of the study area, however, showed no indication of such deposits. Although we cannot conclude absolutely that such deposits are not within the study area, we believe that the probability of an occurrence is low.

INTRODUCTION

LOCATION AND PHYSIOGRAPHY

The Round Lake Wilderness Study Area is about 18 mi east of Park Falls and Fifield, Wis. (fig. 1); it occupies parts of T. 40 N., Rs. 3 and 4 E., in northeastern Price and southwestern Vilas Counties. Access is generally good; the area is bounded by Forest Roads #1182 on the east, #142 on the north and west, and #144 on the south and west. The study area contains one developed recreational facility—a portage trail between Round and Tucker Lakes. Old logging roads and similar primitive trails connect other parts of the area.

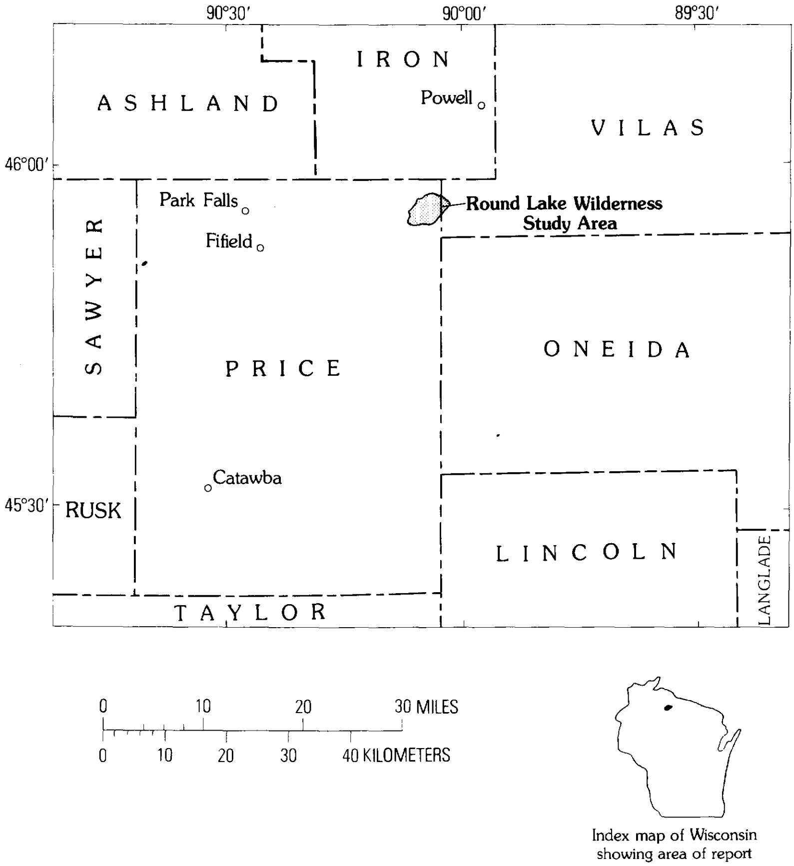

FIGURE 1.—Index map showing the location of the Round Lake Wilderness Study Area and surrounding counties, Wisconsin.

The study area includes approximately 6.5 mi^2 in the glaciated region of northern Wisconsin, where topography and the unconsolidated surface materials are a result of glacial action. Gentle topography (maximum relief is about 100 ft), combined with numerous depressions, has resulted in a relatively poorly drained environment characterized by lakes and swampy areas of standing water. Water covers nearly 750 acres in the study area, which includes parts of Round, Tucker, Jupa, and Ole's Lakes. This area is considered to be the headwaters of the South Fork of the Flambeau River and also includes about 2.5 mi of the river.

Because of glacial deposits, no outcrops are known in the study area. Locally, water wells penetrate about 50 ft of unconsolidated material without reaching bedrock. Glacial drift thickness varies according to changes in topographic relief. In areas of morainal hills and ridges, especially in the northeastern part of the area, drift probably is more than 100 ft thick.

PRESENT INVESTIGATION AND ACKNOWLEDGMENTS

Field investigations were conducted by the U.S. Geological Survey in 1976 and 1977 and by the U.S. Bureau of Mines in 1976. Because no outcrops of bedrock exist in the study area, fieldwork consisted of geophysical surveys, collecting samples for geochemical analysis, sampling peat, and examining a few bedrock exposures outside the study area that may be similar to the bedrock of the study area. In conjunction with field activities, a literature search pertinent to the resource potential of the area was made. Advice was requested from geologists and other local, State, and Federal representatives familiar with the area.

Assistance provided by personnel of the U.S. Forest Service, Chequamegon National Forest, in particular that of Mr. William Byers, Lands Staff Officer, is appreciated.

Samples collected by the U.S. Geological Survey were analyzed for trace elements by the Survey analytical laboratories at Reston, Va. Proximate and ultimate analyses of peat samples collected by the U.S. Bureau of Mines were performed by the U.S. Bureau of Mines, Coal Preparation and Analysis Group, Pittsburgh, Pa., and mineral analyses were completed by the U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nev.

LAND STATUS

The U.S. Forest Service owns all surface land in the wilderness study area; most of the land was purchased as National Forest land in 1968 under authority of the Weeks Act of 1911. No mineral rights are currently outstanding or otherwise reserved. There is no known record of past mining or detailed prospecting activity.

REGIONAL GEOLOGY

The study area is completely mantled by unconsolidated surficial materials, mostly sand and gravel deposited during Pleistocene glaciation; younger peat deposits are also extensive in topographically low areas. Bedrock is not exposed in the study area, and only a few outcrops are known in the region. The bedrock geology is, therefore, poorly known and is inferred, mostly from geophysical measurements and from projection of known bedrock from long distances. The geologic setting is shown in figure 2.

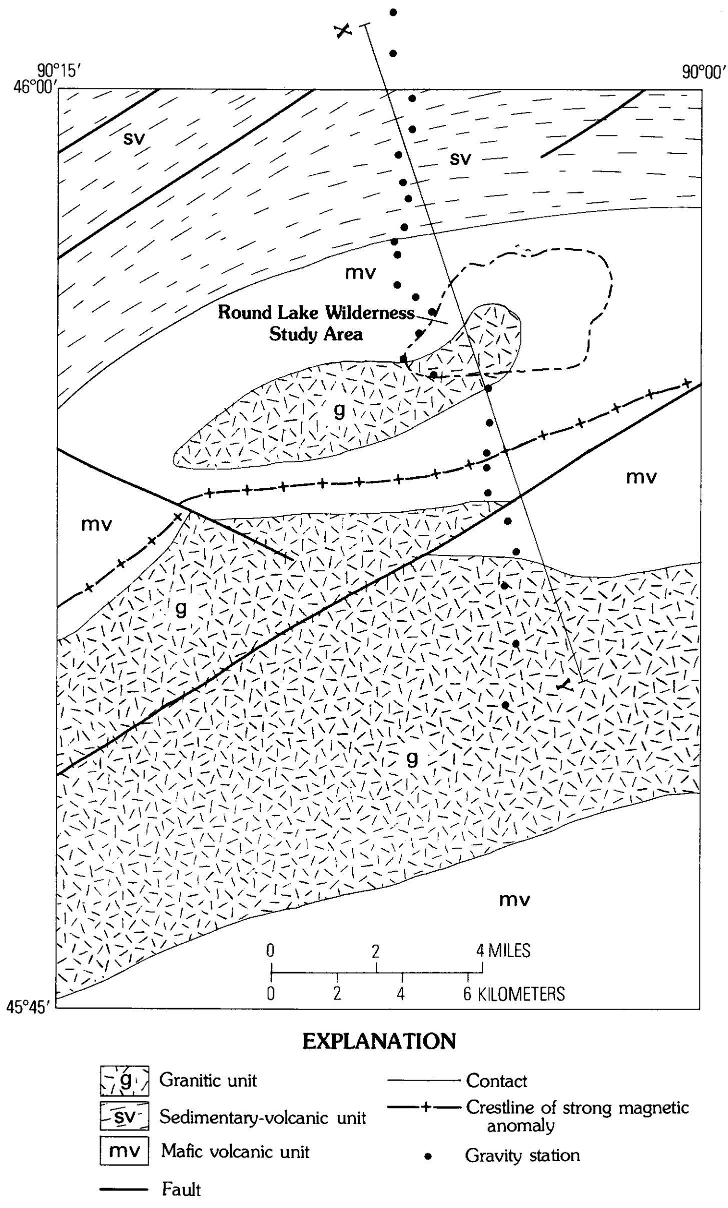

FIGURE 2.—Generalized geologic map of the Pike Lake 15-min Quadrangle, Wis., which includes the Round Lake Wilderness Study Area. Geology from Sims and others (1978). *X–Y*, line of projection of gravity profile that is shown in figure 5.

The study area is in an east-northeast-trending belt of Proterozoic X volcanic rocks, believed to be about 2 billion years old, that have been folded and recrystallized to amphibolite. The belt is defined mostly by an east-northeast-trending zone of strong magnetic attraction (fig. 3) caused by relatively abundant magnetic minerals in the volcanic rocks. A thin zone of even stronger magnetic attraction passing about 1 mi south of the study area is probably caused by a unit of magnetite-bearing iron-formation interlayered with the volcanic rocks.

The volcanic belt is associated with a strong positive gravity anomaly on the gravity map of Wisconsin (Ervin and Hammer, 1974), suggesting that the rocks are mostly mafic, although interlayers of more felsic volcanic rocks are not precluded by the gravity data. The volcanic belt is bounded on the south by granitic rocks (fig. 2), which are slightly younger than the volcanic rocks and which produce an area of uniformly weak magnetic attraction (fig. 3). To the north, the volcanic belt is bounded by a unit of sedimentary and volcanic rocks which are approximately the same age as rocks in the volcanic belt and are similarly folded and recrystallized.

LOCAL GEOLOGY

The geology within the study area can be inferred only from geophysical evidence. Most of the study area (fig. 4) is believed to be underlain by mafic volcanic rocks, which may contain some layers of sedimentary rocks and felsic to intermediate volcanic rocks, although no direct geophysical evidence indicates their existence. The nearest known outcrop of the volcanic rocks is about 5 mi west-southwest of the area along the trend of the positive magnetic anomaly and is hornblende schist (Dutton and Bradley, 1970). Part of the southwest quarter of the area is inferred from magnetic data to be underlain by granitic rocks that intrude the volcanic rocks. The granitic rocks, like those that underlie a much larger area south of the study area, produce an area of low magnetic attraction. The nearest outcrop of the granitic rocks is along the south fork of the Flambeau River about 2.5 mi west-southwest of the place at which the river leaves the study area. There, the granitic rocks are coarse grained and massive and contain many inclusions of older mafic rocks, presumably recrystallized fragments of the mafic volcanic rocks.

The contact between the volcanic and granitic rocks is inferred from the magnetic pattern, although its location is uncertain. Be-

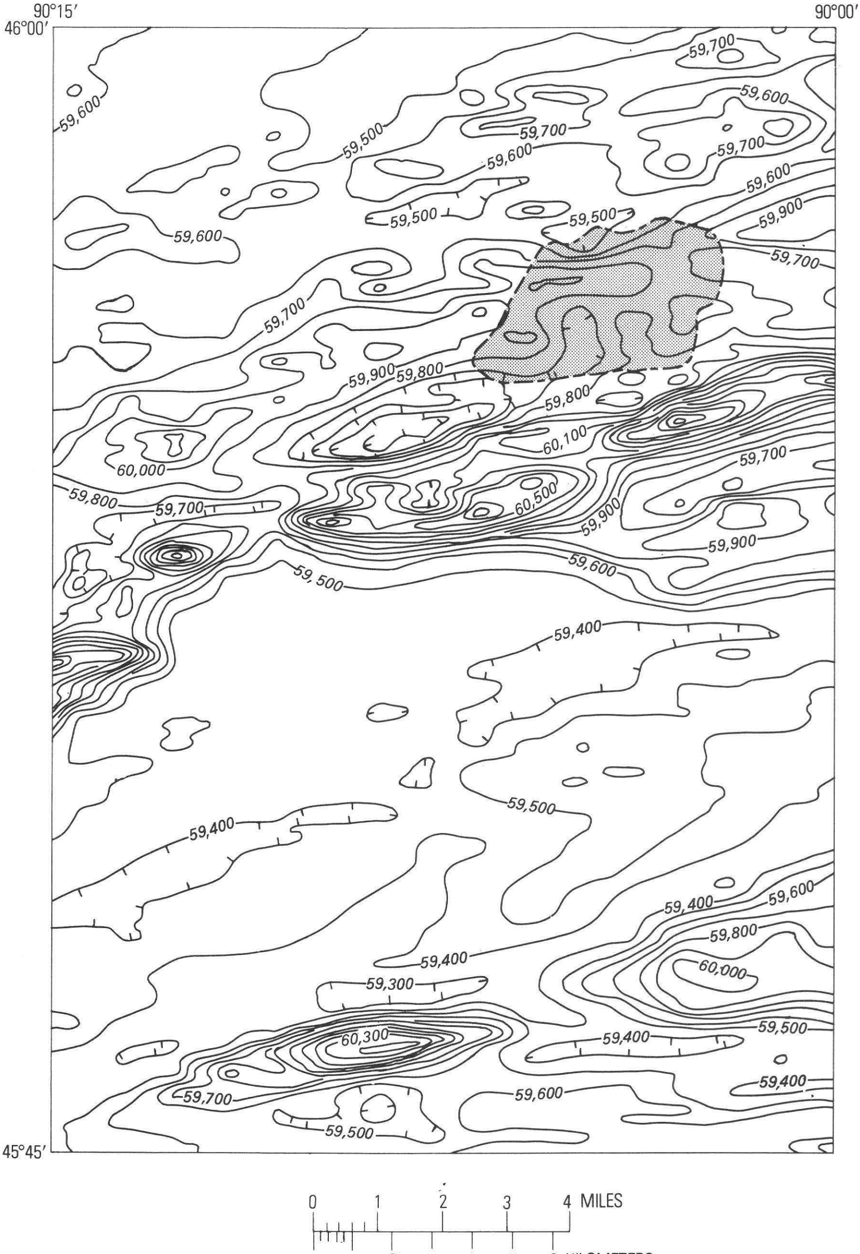

FIGURE 3.—Aeromagnetic map of the Pike Lake 15-min Quadrangle, Wis., which includes the Round Lake Wilderness Study Area (strippled). Aeromagnetic data from Karl and Friedel, 1974. Contour interval 100 gammas. Hachured contours indicate magnetic depression.

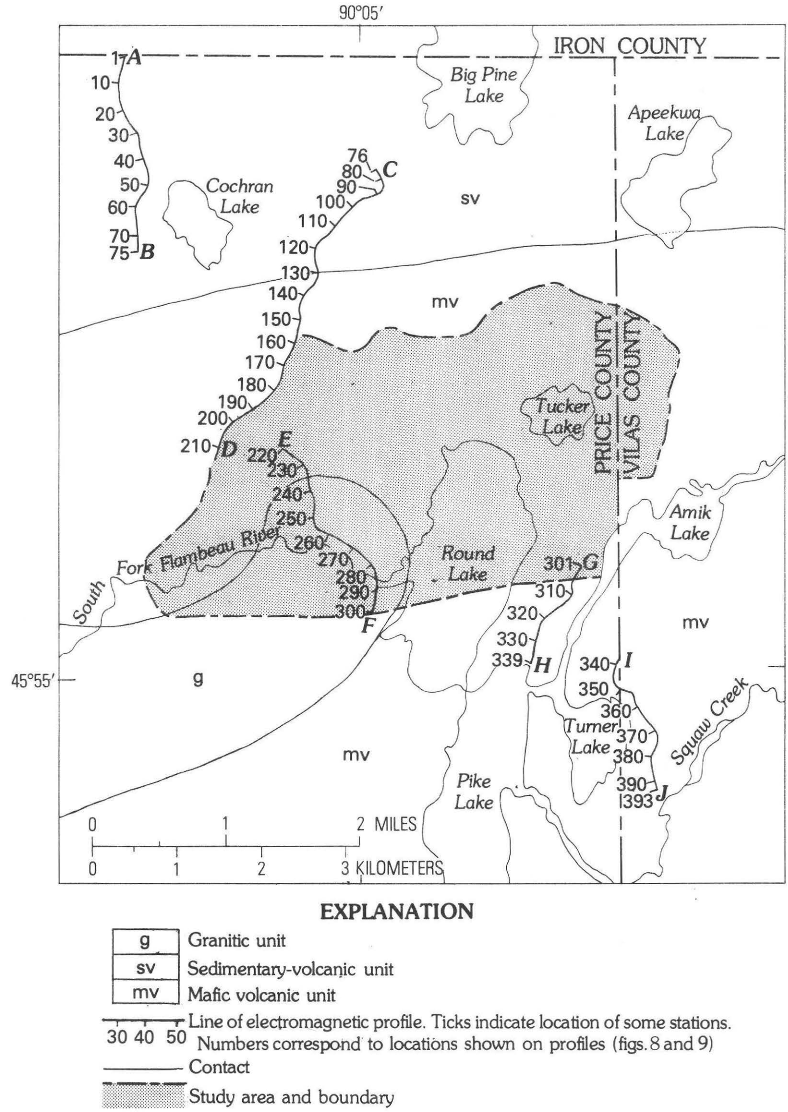

FIGURE 4.—Local geology in and around the Round Lake Wilderness Study Area and locations of electromagnetic profiles (see figs. 8–9).

cause the magnetic gradient is not steep, the location of the contact cannot be placed accurately within the gradient. Also, the magnetic data were measured along north-south flight lines spaced half a mile apart. No more than nine flight lines crossed the area, and no more than five crossed the area of granitic bedrock. Thus, only about five data points can be considered to define the contact.

Likewise, the contact between the volcanic terrane and the sedimentary-volcanic terrane to the north is poorly defined, largely because of the lack of a strong magnetic contrast between the two terranes on the local scale. Although the contact is shown in figure 3 to pass about half a mile north of the area, it might be farther south than shown, and the northern margin of the study area could be underlain by the sedimentary-volcanic unit.

To define the geology of the area better, especially to estimate the vertical distribution of rock units, a gravity profile consisting of 26 stations was measured across the area (figs. 2, 5). The variations in the residual anomaly are caused by horizontal and vertical variations in the density of rocks. Using a method described by Talwani and others (1959), we constructed a density model that is consistent with the observed gravity profile.

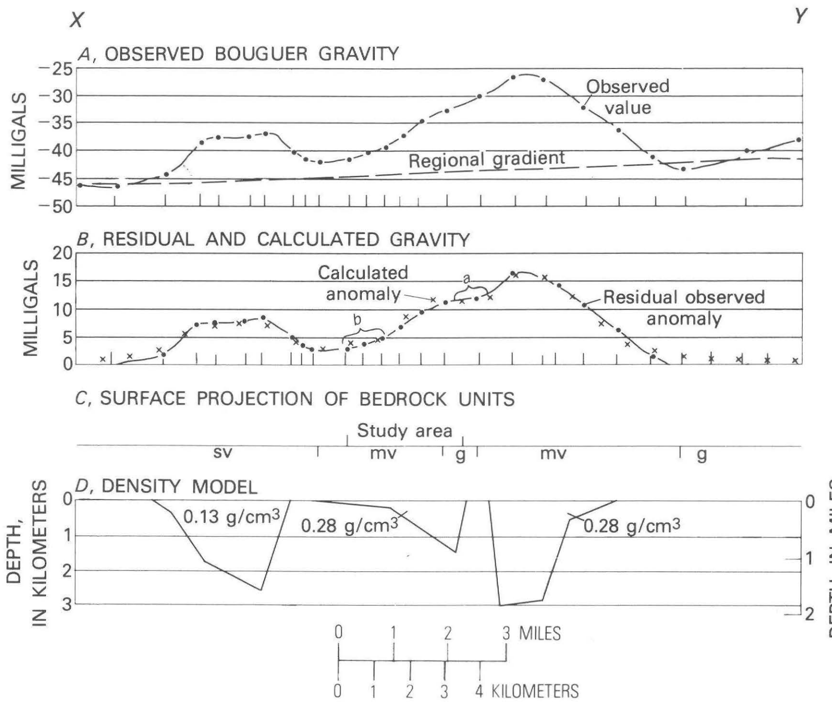

FIGURE 5.—Observed Bouguer gravity profile, residual and calculated gravity profile, surface projection of bedrock units, and density model across the Round Lake Wilderness Study Area. (Line of profile, *X–Y*, in fig. 2.)

A, Observed Bouguer gravity and regional gradient. Ticks on horizontal axis are station locations projected onto the line of profile from the actual point of measurement. Readings were taken by using a LaCoste and

Solutions to the density distribution are not unique because of uncertainties in the density and horizontal distribution of rock units. Also, the method is accurate only if density units are much longer in the direction perpendicular to the profile than in either direction within the profile, a requirement not well met by the granitic unit in the study area. The density model constructed for the study area (fig. 5*D*) uses densities determined for similar rocks in nearby areas (see table 1). Although not a unique solu-

TABLE 1.—*Rock densities used to construct the density model shown in figure 5D*

[Data from Klasner and Cannon (1974) and Cannon and Klasner (1976), and unpublished data from about 25 mi northeast of the study area]

Rock type	Number of samples	Average density (g/cm^3)
Felsic volcanic	4	2.67
Mafic and intermediate volcanic	14	2.97
Metasedimentary	15	2.72
Granite, granitic gneiss	13	2.64

FIGURE 5.—Continued.

Romberg[1] land gravimeter. Some readings were taken at bench marks and other points of known altitude shown on U.S. Geological Survey topographic maps. Altitudes for 16 stations were determined by interpolation between 20-ft contour lines on topographic maps. The simple Bouguer anomaly was computed by using the 1967 International Formula and 2.67 g/cm^3 rock density. No terrain corrections were made. Individual values are considered accurate to the nearest milligal (mGal) only, because of a potentially large error of $\pm$ 0.9 mgal for incorrect altitude and a potential error of $\pm$ 0.2 mGal for incorrect latitude.

B, Residual gravity anomaly produced by removing regional gradient from observed anomaly, and calculated theoretical gravity values produced by the density model shown in *D*. Anomalies at *a* and *b* are discussed in the text.

C, Distribution of bedrock units as projected to the surface along the gravity profile: sv, sedimentary-volcanic unit; mv, mafic volcanic unit; g, granitic unit.

D, Density model drawn to conform approximately to surface projection of bedrock types. The densities were determined by using the data in table 1. Granitic rocks were assigned a density of 2.64 g/cm^3. The sedimentary-volcanic unit was assumed to be 80 percent graywacke and 20 percent mafic and intermediate volcanic rocks, yielding a density of 2.77 g/cm^3. Thus, the density contrast is 0.13 g/cm^3. The mafic volcanic unit was assumed to be composed of 80 percent mafic and intermediate rocks and 20 percent felsic rocks, giving a density of 2.92 g/cm^3 or a density contrast of 0.28 g/cm^3.

[1] Use of trade names in this publication is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

tion, the model provided some useful additional information on the geology of the area.

Within the study area, the existence of a granitic body is supported by a large shoulder in the residual anomaly (at *a* in fig. 5*B*) that in the calculated profile is caused by a unit of light (2.6 g/cm^3) rock coming to the surface. Toward the northern edge of the study area (*b* in fig. 5*B*), the anomaly is small, indicating that mafic rocks are scarce or absent. Possible interpretations are: (1) The mafic volcanic unit is very thin and underlying rocks are near the surface, (2) the area is underlain by felsic rather than mafic volcanic rocks, or (3) the area is underlain by the sedimentary-volcanic unit inferred to be present to the north. The data do not allow us to infer which of these alternatives is most likely.

If the densities used in the model are nearly correct, the vertical extent of the mafic volcanic rocks is about 2 mi. The sedimentary-volcanic unit north of the area is also roughly 2 mi deep.

IDENTIFIED RESOURCES

Peat and sand and gravel are the only identified resources in the Round Lake Wilderness Study Area. Both have very low potential for commercial development.

PEAT

Peat is broadly classified as marsh or reed-sedge according to the dominant types of plant material from which it is formed; humus is peat so decomposed that identity of plant material is lost. According to the American Society for Testing and Materials (1969, D2607–69), the term "peat" may be used to identify commercial agricultural peat only if it has an ash content not exceeding 25 percent on a dry-weight basis.

Virtually all peat presently sold in the United States is for agricultural purposes. In 1976, 86 percent was sold for general soil improvement, and the remaining 14 percent for use in potting soils (Mickelsen, 1976). Estimates of resources of peat to be used for agricultural purposes are based on obtaining 200 short tons of air-dried peat from 1 acre-ft of material in place. Sheridan and De Carlo (1957) estimated that Wisconsin contains 1,500 mi^2 of peat lands capable of yielding 2.5 billion short tons of air-dried peat. Their estimate was based on the assumption that commercial-quality deposits average at least 5 ft in thickness.

The growing shortage of fossil fuel has caused a hard look to be directed at peat as an alternate source of energy. Peat is found in many parts of Wisconsin on the poorly drained surface of glacial drift within the generalized areas shown in figure 6.

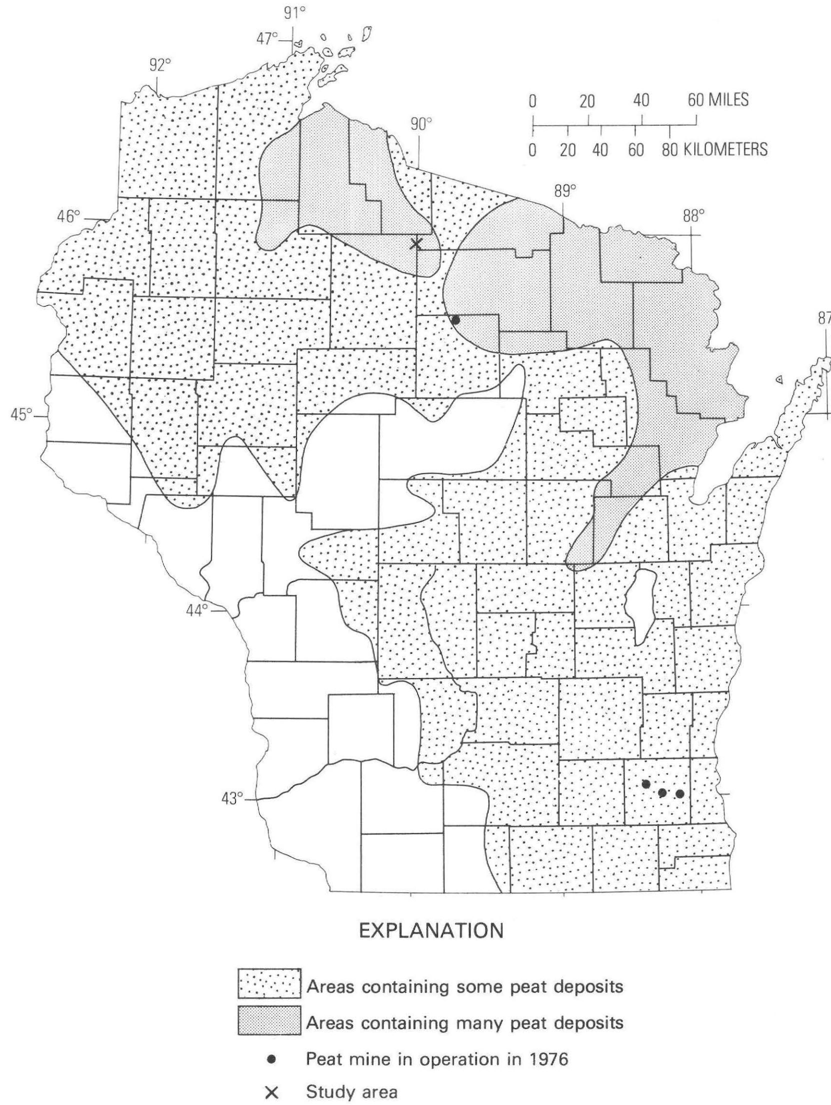

FIGURE 6.—Location of the Round Lake Wilderness Study Area in relation to the distribution and density of peat deposits in Wisconsin and the locations of peat mines in operation in 1976. Modified from map by Cameron (1976).

According to Dr. R. S. Farnham, Professor of Soils Science, University of Minnesota (written commun., 1977), the potential energy available from all the 4,500 mi^2 of Wisconsin peatlands mapped by the Soil Conservation Service, U.S. Department of Agriculture (USDA), for the USDA Conservation Needs Inventory Committee (1971), would be 77 quadrillion Btu's. Quality standards of peat for use as a fuel have not been made yet.

The stratigraphy of the peat deposits of the Round Lake area reflects a history of organic and inorganic accumulation in lakes and ponds occupying depressions in the kame-and-kettle topography on the glacial drift. The organic material consists of the remains of long-stemmed and floating aquatic plants that lived in relatively shallow water. The ash content of this material ranges from 5 percent to 28 percent, generally depending upon the amount of clay laid down with the plant material.

In the Round Lake Wilderness Study Area, deposits that have an ash content of more than 25 percent are generally reed-sedge peat that formed as marsh-type vegetation took over and water became more shallow. A moss carpet begins to form as soon as standing water vanishes, and moss peat then builds up in one or more domes over the pond site. Cores at sites 140–144 and 149–151 (pl. 1) illustrate this normal sequence of events.

Forest fires and flooding caused by beaver and manmade dams change the normal sequence and the kind and amount of peat. For example, sphagnum peat rests immediately upon silt at sites 137–139, 147, and 148. Significant amounts of charcoal at the base of the moss peat at sites 137 and 147 suggest that the present sphagnum peat formed after forest fires burned the original peat. The core at site 145 illustrates a history of burning followed by formation of a new pond, which became marsh that was flooded by the rise of Amik Lake level (see silt below the sample depth location, pl. 1); sphagnum is just now beginning to accumulate over reed-sedge peat at this site.

The amount of commercial-quality peat in the Round Lake Wilderness Study Area, therefore, has been reduced through fire and flooding; burning and the introduction of silt raised the ash content. The peat-resources estimate is also reduced by elimination of deposits less than 5 ft thick because they are not considered worth exploiting by most peat producers. Figure 7 shows the distribution of commercial-quality agricultural peat in the Round Lake Wilderness Study Area.

EXPLANATION

Commercial-quality peat (ash content less than 25 percent dry weight) having average thickness greater than 5 feet

--- Boundary of study area

FIGURE 7.—Location and extent of commercial-quality agricultural peat in the Round Lake Wilderness Study Area.

At present, the Round Lake Wilderness Study Area peat resources having ash contents less than 25 percent in deposits 5–15 ft thick are estimated at 760,000 short tons, air dried. Of this amount, 451,000 short tons is in deposits north and east of Round Lake, deposits that are generally flooded:

Sec. 18, T. 40 N., R. 4 E.—54 acres at an average thickness of 10 ft = 110,000 short tons.

Sec. 13, T. 40 N., R. 3 E.—93 acres at an average thickness of 10 ft = 187,000 short tons.

Sec. 24, T. 40 N., R. 3 E.—80 acres at an average thickness of 10 ft = 154,000 short tons.

In view of the large amount of peat available for agricultural purposes elsewhere in Wisconsin, this resource in the study area is not likely to be developed soon.

Peat, because of its high carbon content, is used as a fuel in many European countries that lack alternate sources of energy. Worldwide, more than half the peat produced is utilized as a fuel —from individual home use to generation of electricity. Analyses (table 2) of peat collected from the study area show that

TABLE 2.—*Analyses of peat samples collected*

[Analyses by U.S. Bureau of Mines, Coal Preparation and Analysis Group, Pittsburgh, Pa.

		Proximate analyses (weight percent)				
Bog number (pl.1)	Condition of sample[1]	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen
1	AR	64.3	22.6	10.2	2.9	9.2
	MF	----	63.3	28.6	8.1	5.6
	MAF	----	68.9	31.1	---	6.1
2	AR	66.4	21.9	9.6	2.1	9.2
	MF	----	65.1	28.6	6.3	5.5
	MAF	----	69.5	30.5	---	5.9
5	AR	65.0	22.7	10.1	2.2	9.1
	MF	----	64.9	28.9	6.2	5.4
	MAF	----	69.2	30.8	---	5.7
6	AR	63.3	22.3	10.3	4.1	8.9
	MF	----	60.7	28.0	11.3	5.1
	MAF	----	68.5	31.5	---	5.8
8	AR	72.2	19.5	7.1	1.2	9.6
	MF	----	70.2	25.5	4.3	5.7
	MAF	----	73.4	26.6	---	6.0

[1]Symbols used: AR, as received; MF, moisture-free; MAF, moisture-

from the Round Lake Wilderness Study Area

Locations of samples are shown in pl. 1; samples 3, 4, and 7 were not analyzed]

Ultimate analyses (weight percent)

Carbon	Nitrogen	Sulfur	Oxygen	Ash	Heating value (BTU/lb.)
20.0	0.7	0.1	67.1	2.9	3,506
56.2	1.8	0.3	27.9	8.1	9,834
61.2	2.0	0.3	30.4	---	10,704
18.3	0.5	0.1	69.8	2.1	3,149
54.5	1.5	0.2	32.0	6.3	9,369
58.2	1.6	0.2	34.2	---	10,004
18.7	0.5	0.1	69.3	2.2	3,200
53.6	1.6	0.2	33.0	6.2	9,149
57.1	1.7	0.3	35.2	---	9,754
19.5	0.7	0.1	66.6	4.1	3,337
53.2	2.0	0.3	28.2	11.3	9,099
59.9	2.2	0.3	31.8	---	10,260
14.3	0.3	0.1	74.6	1.2	2,412
51.4	1.1	0.2	37.3	4.3	8,691
53.7	1.1	0.2	39.0	---	9,079

and ash-free.

moisture-free samples have an average value of 9,228 Btu's per pound, approximately that of lignite. This moisture-free value, however, is valuable only for comparison purposes, as moisture cannot be completely removed economically. The most feasible method of moisture removal on a large scale is air-drying, a process by which the cut peat is left outdoors for weeks or months and allowed to dry naturally. Huels (1915, p. 115) determined the average moisture content of air-dried Wisconsin peat to be nearly 27 percent, depending upon weather conditions. Samples submitted for analysis and included in this report were dried for only several days, hence, the high moisture content in "as received" measurements. Assuming that an average of 27 percent moisture content is obtainable for air-dried peat from the study area, mathematical conversions can be made for reported heating value in table 2 by using the formula: heating value (at 27 percent moisture) =

$$\text{reported heating value (moisture-free)} \times \left(1 - \frac{27}{100}\right)$$

According to this formula, the average Btu value of peat sampled is 6,737 per pound. Similarly, the ash and sulfur contents in the partly dried peat are corrected to 73 percent of the averages of values listed in table 2; thus, the ash content averages 5.3 percent, and sulfur is about 0.18 percent. For comparison, about 2 short tons of air-dried peat is equal to 1 short ton of coal from the standpoint of heating value. The study area, then, contains the equivalent of possibly as much as 420,000 short tons of coal, but more than half of this is in deposits that are generally flooded. This total does not constitute a large resource, but when combined with tonnages from lands adjoining the study area, it could become significant if peat were considered as a fuel. Unless peat becomes a viable energy source in the United States, production from bogs in the Round Lake area is unlikely.

SAND AND GRAVEL

Although glacial drift, consisting mostly of stratified sand and gravel deposits, covers the study area, little potential exists for commercial development of these deposits. The Round Lake area is somewhat isolated from current demand centers, and sand and gravel are abundant regionally. Future demand would be based ultimately on transportation costs to markets, and resources in the study area could not compete economically with similar deposits found nearer transportation facilities.

POTENTIAL FOR UNDISCOVERED MINERAL DEPOSITS

No direct evidence suggests the presence of undiscovered mineral deposits in the study area. The thick cover of surficial material on bedrock renders equivocal all exploration techniques used, so that the existence of undiscovered deposits cannot be completely ruled out.

Regional geology indicates that massive sulfide ores of copper, lead, or zinc constitute the type of deposit most likely to exist in the study area. Belts of volcanic rocks in Wisconsin and elsewhere are known to contain massive sulfide ores. Such deposits are generally lenses of rock very rich in sulfide minerals that are parallel to the primary layering of the enclosing volcanic rocks. In Wisconsin, such deposits have been found in several locations in the past 10 years. All are in volcanic rocks about the same age as those of the study area. Hence, the rocks in the study area should be considered potential hosts for massive sulfide deposits.

On a worldwide basis, massive sulfides are typically in felsic volcanic rocks near contacts with mafic volcanic rocks. Most of the volcanic rocks of the study area are believed to be mafic because of the positive gravity anomaly that they produce. However, as discussed above, the gravity data do not preclude the existence of felsic rocks and, in fact, indicate that felsic rocks might exist in the northern part of the area.

Geochemical and electromagnetic surveys were performed to evaluate the possibility that massive sulfide deposits are present.

GEOCHEMICAL SURVEYS

Two types of samples were used in the geochemical surveys: (1) soil samples collected about 1 ft below the surface, and (2) peat samples collected by augers from the extensive bogs in the area.

Soil samples.—Soil samples from 20 localities in the area (pl. 1, *A*) were analyzed for trace elements by a semiquantitative spectrographic technique at the U.S. Geological Survey analytical laboratories in Reston, Va. All samples are reddish-brown sandy soil developed on glacial drift. Values in parts per million (ppm) for copper (Cu), lead (Pb), and zinc (Zn), three elements common in massive sulfide deposits, are shown in plate 1, *A*. If a massive sulfide deposit is buried beneath surficial material, these and other elements associated with it might accumulate in soils near the deposit as a result of transport of the elements in ground water and deposition in the soil horizon. For example, Cu and Zn are clearly anomalous in soils near the deposit at Ladysmith, Wis. (May, 1976). Copper values there are as high as 20 ppm, about four times background, and Zn values are as high as 100 ppm, about three times background. At the Ladysmith deposit, glacial drift is only 10–30 ft thick, probably less than the average thickness in the study area; thus, some doubt exists whether a buried massive sulfide in the study area would have similar expression in soils. The data shown in plate 1, *A* for soil samples contain no Cu, Pb, or Zn values that we consider significantly anomalous. Contents of these metals in peat are somewhat higher and are discussed below in a separate section. Copper values appear to have a higher background value here than at Ladysmith. About 20 ppm Cu is believed to be typical background for soil in the Round Lake area. Only one soil sample, that near the northwest corner of sec. 22, has a Cu content substantially higher than the background value (57 ppm); this value is not believed to be significant, however, because two peat samples nearby do not indicate significant copper concentration. Lead and zinc values are uniformly low. All zinc values are well within the range reported for samples from Ladysmith. Lead content was not determined at Ladysmith.

The soil samples were analyzed for 55 trace elements by the semiquantitative technique. Many elements were missing or were present in quantities below the detection limits of the technique. Of those detected, none are present in anomalously large concentrations.

Peat samples.—Twenty peat samples were analyzed geochemically; 15 by the U.S. Geological Survey and 5 by the U.S. Bureau of Mines. Locations of all samples are shown in plate 1, *A*. Plate 1 shows the stratigraphic location within the peat bog of each sample collected by the U.S. Geological Survey. Analyses were performed on the ash remaining after combustion of the peat. The ash content for each sample is also shown in plate 1, *A*.

Although the organic matter in peat should be a potent concentrator of trace elements from water passing through it, the Cu, Pb, and Zn values of ash are uniformly low. Because the ashing process results in element concentrations about 4 to 20 times greater than their original concentration in the peat, the values shown indicate that the original peat samples contained trace elements in concentrations at most about twice those in surrounding soils. None of the values determined for peat is believed to indicate a mineral deposit.

ELECTROMAGNETIC SURVEYS

Electromagnetic surveys can detect electrically conductive rock bodies in the shallow subsurface. If a rock contains electrically conductive minerals in great enough abundance so that the minerals form a connecting framework through the rock, the rock body may conduct electricity. Many types of rocks, including massive sulfide bodies, are conductive, and electromagnetic surveys are an important and frequently used tool in massive sulfide exploration.

In the study area, we performed a reconnaissance survey using a very low frequency-electromagnetic (VLF-EM) technique to search for conductive rocks. The VLF-EM technique detects perturbations in an electromagnetic field that might be caused by conductive rocks. The technique uses electromagnetic waves in the 15–25 kilohertz (kHz) frequency range; the waves are generated by transmitters in different parts of the world that are used principally for military communication. A transmitter located roughly along the long axis of an elongate conductive body generates electromagnetic waves that, upon intersecting the body, induce an electrical current in the body; that is, the body acts as a receiving antenna. The current flowing through the rock generates a secondary electromagnetic field that causes a perturbation in the inducing transmitted field. A VLF–EM instrument measures two components of the total electromagnetic field thus generated. These are called the "in-phase" and "quadrature" components and are a reflection of the intensity of perturbation of the inducing field and, therefore, also are a measure of the conductivity of the rock. Both components are recorded as degrees of dip of sensing coils in the instrument, so that the value of the dip angle is proportional to the intensity of the measured component. The ratio between the in-phase and quadrature components is a function of conductivity in the underlying rock.

In our survey, a Geonics EM–16 unit was used. The VLF–EM transmitter at Cutler, Me. (17.8 kHz), was selected because massive sulfide bodies, if present, are likely to be oriented with their long axis approximately east-west, parallel to the trend of the volcanic belt. Three hundred and ninety-three readings were made at 100-ft intervals along five profiles (fig. 4). The profiles (figs. 8, 9) were located so as to provide a complete section of rocks through the study area and to ensure the least possible interference from manmade features such as buried cables, pipelines, and powerlines.

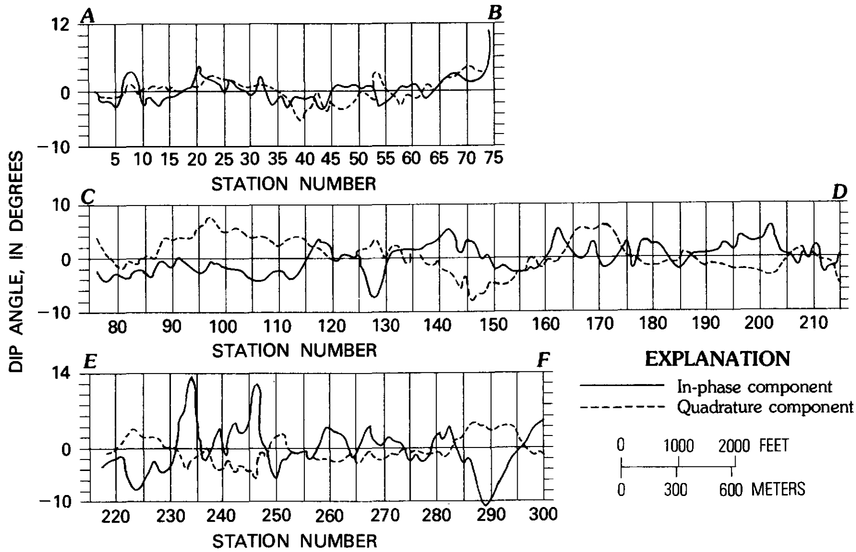

FIGURE 8.—Very low frequency electromagnetic profiles *A–B, C–D,* and *E–F* measured in and near the Round Lake Wilderness Study Area. Station locations are shown in figure 4.

Within the study area and to the northwest (profiles *A–B, C–D, E–F*, fig. 8), the profiles give no indication of conductive bedrock. Most dip values are small, less than 10°, and the larger of these are related to surface conductive features such as swamps, rivers, and buried cables. On profile *G–H* (fig. 9), a conductive body is indicated at about station 311, about 0.2 mi south of the study area. On profile *I–J*, a conductive body is indicated at about station 383, about 1.4 mi south of the study area. At both stations, conductive bedrock is indicated by strongly negative in-phase values and positive quadrature values just south of these stations. The conductive body is at the crossover point (point where dip value changes sign) for the in-phase component. Because of the presence of these anomalies, the data for these profiles were filtered, using a method devised by Fraser (1969) to smooth the data and make them easier to interpret. In the filtered profiles (fig. 9), the conductive rock bodies are represented by the positive peaks of the filtered in-phase values. The nature of the conductive bodies is not known. Although they might be massive sulfide bodies, they are perhaps more likely caused either by electrolytic solutions in fault zones or by layers of conductive metasedimentary rocks, such as graphitic schist.

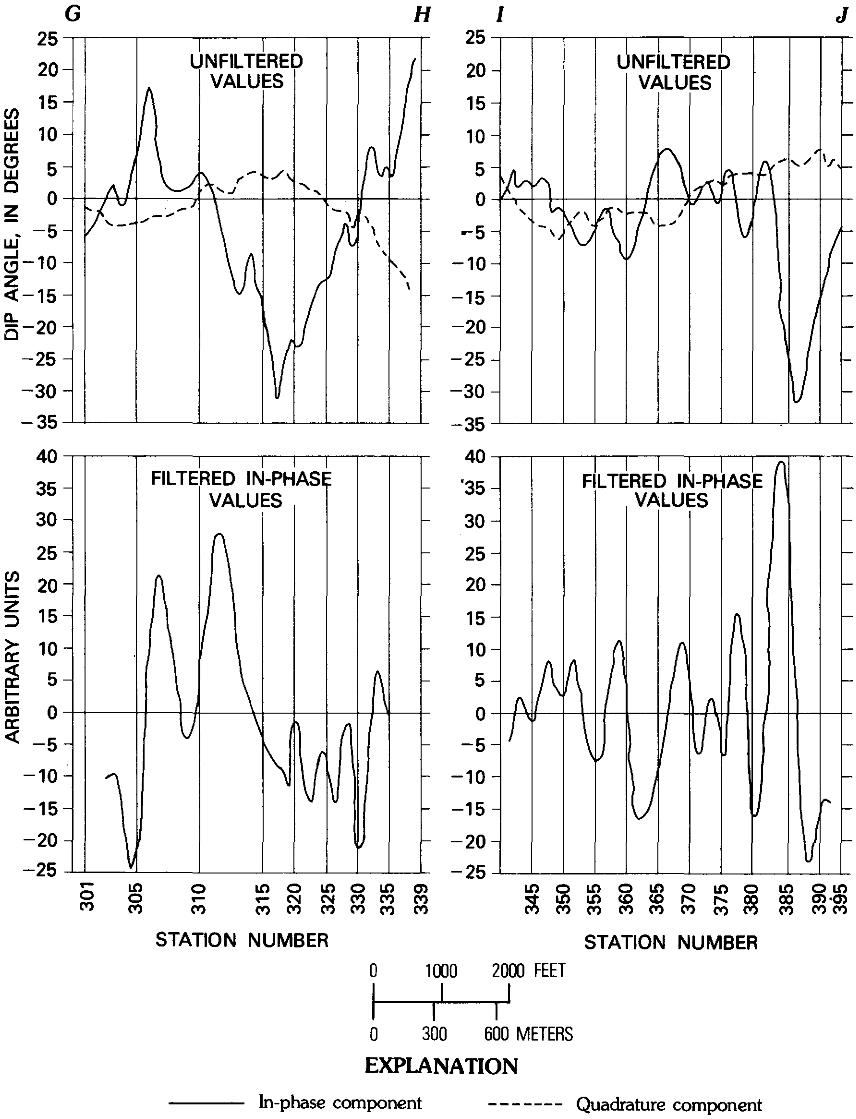

FIGURE 9.—Very low frequency electromagnetic profiles *G–H* and *I–J* measured in and south of the Round Lake Wilderness Study Area, showing anomalies caused by two conductive bodies. Upper profiles are direct instrument readings. Lower profiles are filtered data that show positive peaks over the conductive bodies. Station locations are shown in figure 4.

Because the anomalies are outside the study area and are not likely to extend into the study area, they were not examined further. They are important, however, in that they suggest that the

VLF–EM technique is able to detect conductive bedrock through the surficial deposits in this area. We can conclude with some confidence, therefore, that the absence of electromagnetic anomalies on the profiles in the study area truly indicates a lack of conductive rock.

CONCLUSIONS

The Round Lake Wilderness Study Area contains peat equivalent to 760,000 short tons of air-dried peat of commercial quality suitable for agricultural purposes or fuel. The area also contains large quantities of sand and gravel. Because very large quantities of both commodities of comparable quality exist in other parts of Wisconsin closer to transportation facilities and consumption points, the economic potential of these commodities in the study area is very low.

The study area is underlain by metamorphosed volcanic rocks similar to those in which massive sulfide ores of copper, lead, and zinc have been found at other places in Wisconsin. Geochemical and geophysical surveys of the study area found no indication of the presence of massive sulfides or other types of deposits. Although the presence of thick surficial deposits makes these surveys less than conclusive, the mineral-resource potential of the study area must be considered low.

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